Volume 29 February 26, 1954 Number 2

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME OF THE

1954 AUSTIN MEETING

AT

AUSTIN, TEXAS

February 26–27, 1954

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
EIGHT ISSUES EACH YEAR

BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published eight times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published eight times a year, once in January, once in February, once in March, once in April, once in June, once in July, once in November, and once in December, at Prince and Lemon Streets, Lancaster, Pennsylvania.

Entered as second class matter, December 27, 1949, at the post office at Lancaster, Pa., under the Act of August 24, 1912.

Acceptance for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948, authorized Nov. 30, 1948.

February 26, 1954 Vol. 29, No. 2

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

1954 FEBRUARY MEETING AT AUSTIN, TEXAS, FEBRUARY 26–27, 1954

THE **1954 February meeting of the American Physical Society** will be held on Friday and Saturday, February 26 and 27, 1954, at Austin, Texas, in the buildings of the University of Texas. This will be our first meeting at Austin and our third in the state of Texas. It is intended to set a precedent for the holding of one meeting every year in the "Southwest," an area roughly defined for the present purpose as extending from St. Louis in the north to Mexico City in the south, and from the Mississippi River in the east to an indefinite meridian west of the state of Texas but not infringing on the Coast. Although February has been tentatively chosen as the usual month for these meetings, that of 1955 will probably be the one to be held in Mexico City late in August or early in September. Austin starts the series with a programme of about the same size as that of the Houston meeting of November, 1951: it remains to be seen how rapidly these programmes will expand. The Chairman of the Local Committee is Professor E. L. Hudspeth of the University of Texas.

The **official hotel** is the Driskill, at 122 East Sixth Street. Rates begin at $4 for single rooms, $6.50 for double room with double bed, $7 for double room with twin beds. Reservations should be made right away by letter to the hotel, with mention of the Society. Information about tourist courts will be supplied on request by Professor E. L. Hudspeth, University of Texas, Austin 12, Texas. The University is somewhat over a mile from the hotel: taxis are recommended for those who do not care to walk.

The **registration desk** will be set up in Batts Auditorium of the University. All members and guests are asked to register and to pay a registration fee of one dollar, and they are advised to keep an eye on the nearby bulletin board for notice of messages.

Sixty-two contributed papers have been distributed among seven sessions. At the smaller meetings, of which this is an example, session titles are less specific than at the larger meetings, for there is a greater variety of topics grouped under most: this is especially illustrated by the session entitled "General Physics."

Invited Papers. Friday morning is reserved for a single session composed of four invited papers by D. S. Hughes, A. C. G. Mitchell, Dudley Williams, and Walter Gordy. Other half-days offer three sessions each. On Friday afternoon there is a group of four invited papers (J. H. Crawford, J. J. Lander, C. F. Squire, and J. M. Reynolds) in solid-state physics, the last two pertaining to the low-temperature range. Nine invited papers in nuclear physics (C. M. Class, B. L. Cohen, M. Goodrich, F. L. Hereford, N. Nereson, I. Perlman, J. A. Phillips, M. S. Vallarta, and W. Whaling) are distributed among other sessions. Most of these invited speakers are of the Southwest and the Southeast, but there are some who are coming from farther away.

The **banquet of the Society** will be held on Friday evening at seven in the Crystal Ballroom of the Hotel Driskill: price, $2.85; attire, informal. The after-dinner speaker will be Professor W. P. Webb of the University of Texas. Advance reservations should be made by use of the form on the inside back-cover page. The deadline hour for purchase of tickets will be announced on the bulletin board near the registration desk, look for it as soon as you arrive, for it may come at an early hour. The tickets will be sold at the registration desk.

A **cocktail hour** has been generously offered to members of the Society by the Austin *American-Statesman*. The scene will be the Hotel Driskill, and the "hour" will commence at six o'clock.

Council of the American Physical Society. No Council meeting is planned for Austin. If an emergency requires one, the Councillors will be notified by special message.

Post-deadline ten-minute papers, pertaining to very recent achievements of very special importance, will be considered for admission to a supplementary programme if the abstracts are received at the office of the Society (the address below) not later than Friday, February 20. The titles of such papers as may be accepted will be announced on a blackboard near the registration desk, and the papers will be given under the usual ten-minute rule at the end of Session I.

For **prospective meetings of the Society** and the corresponding deadlines, see page 5 of this Bulletin.

Titles and abstracts of the papers contributed to the 1953 February meeting are printed hereinafter, and in exactly this form they will appear in an early issue of *The Physical Review*. Errata will be printed on an adjacent page of *The Physical Review* if received not later than Friday, March 12, by Miss Ruth Bryans, American Institute of Physics, 57 East 55 Street, New York 22, New York. Do not send in the abstract marked with corrections: write out the corrections in the form "Instead of . . . read. . . ." Add nothing.

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University
New York 27, New York

Second Announcement of the 1954 Washington Meeting

The 1954 Washington Meeting will be held on Thursday, Friday, and Saturday, April 29, 30, and May 1. Deadline date is Friday, February 19. For information about hotels, see page 5 of the Annual Meeting Bulletin.

MEETINGS AND DEADLINES FOR THE SEASON 1953–1954

I. Meetings east of the Rockies

Place	*Meeting dates*	*Deadline date*
Austin	February 26–27	past
Detroit-Ann Arbor	March 18–20	past
Washington	April 29–30, May 1	February 19
Minneapolis	June 28–30	April 30

Abstracts of contributed papers for the foregoing meetings are to be sent to Karl K. Darrow, American Physical Society, Columbia University, New York 27, New York. To avoid danger of confusion, please do not send abstracts for any meetings until the deadline date of the previous meeting is past.

II. Meetings west of the Rockies

Seattle	July 7–10, 1954	May 5, 1954

Abstracts of contributed papers for the Seattle meeting are to be sent to J. Kaplan, University of California, Los Angeles 24, California.

RULES IMPOSED ON ABSTRACTS

The Council has ordered that abstracts shall be not longer than two hundred (200) words or the equivalent thereof. In reckoning equivalence, a footnote is equated to ten words; each line in a table to ten words; a "display" formula—one that requires a line to itself—is an expensive luxury equated to forty words.

Two copies of each abstract must be sent to the appropriate office. They must be typewritten and double spaced; one must be an original, the other may be an original or a carbon copy. Each abstract must be confined to a single page: if it is too long for a single page it is too long to be printed. Write each abstract as a single paragraph: the suppression of paragraphs costs time and labor to the editors. Look at the abstracts in this *Bulletin* to see how the title of the paper and the name of the author are to be arranged and follow the example. Issues of the *Bulletin* are sometimes appreciably delayed because the editors have to do what the authors should have done.

Remember the rule of the Council that, if an author submits more than one abstract, all but one must go onto the Supplementary Programme. In enforcing this rule, an abstract is credited to the author whose name appears first in the by-line.

The use of special delivery is perilous. For reasons which we do not pretend to understand, special-delivery stamps sometimes produce the inverse of the effect expected. Telegraphed abstracts will no longer be accepted.

EPITOME OF THE 1954 AUSTIN MEETING

(Personal names are those of invited speakers.)

Friday Morning

A. Hughes, Mitchell, Williams, Gordy. Batts Auditorium.

Friday Afternoon

B. Crawford, Lander, Squire, Reynolds. Physics 203.

C. Perlman, Goodrich, Cohen; nuclear physics, I. Batts Auditorium.

D. Molecular spectroscopy; atomic physics. Physics 201.

Friday Evening

Banquet of the American Physical Society. Crystal Ballroom, Hotel Driskill. W. P. Webb.

Saturday Morning

E. Hereford, Phillips, Whaling, Nereson, Vallarta. Batts Auditorium.

F. Nuclear physics, II. Physics 203.

G. Solid-state physics; cryogenics. Physics 201.

Saturday Afternoon

H. Class; nuclear physics, III. Batts Auditorium.

I. Magnetic resonance; post-deadline papers, if any. Physics 201.

J. General physics. Physics 203.

PROGRAMME

FRIDAY MORNING AT 10:00

Batts Auditorium

(E. L. HUDSPETH presiding)

Invited Papers

A1. Thermodynamic Properties of Solids Deduced from High-Pressure Measurements. D. S. HUGHES, *University of Texas.* (30 min.)

A2. Recent Advances in Nuclear Spectroscopy. A. C. G. MITCHELL, *Indiana University.* (30 min.)

A3. Recent Developments in Radio-Frequency Spectroscopy. DUDLEY WILLIAMS, *Ohio State University.* (30 min.)

A4. Millimeter and Submillimeter Wave Spectroscopy. WALTER GORDY, *Duke University.* (30 min.)

FRIDAY AFTERNOON AT 2:00

Room 203, Physics Building

(W. V. HOUSTON presiding)

Invited Papers in Solid-State Physics

B1. Nucleon Bombardment of Semiconductors. J. H. CRAWFORD, *Oak Ridge National Laboratory.* (30 min.)

B2. Chemical Observations on Nonstoichiometric Zinc Oxide and Interpretation of Its Conductivity. J. J. LANDER, *Bell Telephone Laboratories.* (30 min.)

B3. The Effect of Pressure on Superconductivity. C. F. SQUIRE, *Rice Institute.* (30 min.)

B4. The Periodic Hall Effect at Low Temperatures. J. M. REYNOLDS, *Louisiana State University.* (30 min.)

FRIDAY AFTERNOON AT 2:00

Batts Auditorium

(J. G. POTTER presiding)

Invited Papers in Nuclear Physics

C1. Nuclear Spectroscopic States Deduced from Alpha Decay. I. PERLMAN, *University of California, Berkeley.* (30 min.)

C2. Recent Scintillation—Spectrometer Measurements at Louisiana State University. MAX GOODRICH, *Louisiana State University.* (30 min.)

C3. Angular Distribution of Products from 22-Mev Proton Reactions. B. L. COHEN, *Oak Ridge National Laboratory.* (30 min.)

Nuclear Physics, I

C4. Angular Correlation Apparatus for the $Li^7(p,\gamma,\alpha)He^4$ Reaction.* PAT M. WINDHAM AND G. C. PHILLIPS, *The Rice Institute.*—Angular correlation studies are being attempted in the reaction $Li^7(p,\gamma,\alpha)He^4$. This information would permit assignment of the angular momentum of the states involved. The alpha particles that are emitted from the 3-Mev excited state in Be^8 are analyzed at 90° to the beam by means of a magnetic spectrometer of about 4 percent resolution. The alpha particles are deflected through 30° and then are detected by means of a KI(Tl) scintillation counter that subtends a solid angle of 1/675 steradian at the end of a tube some 150 cm from the center of the magnet. The γ rays are detected by means of a NaI(Tl) scintillation counter that can be rotated in space about the target assembly. The γ-ray and alpha-particle pulses are fed into a coincidence circuit with a resolving time of about 10^{-8} second. The operation of the analyzer and coincidence apparatus will be discussed in addition to a brief presentation of theoretically expected correlation for various reasonable assignments of angular momenta.

* Supported by the U. S. Atomic Energy Commission.

C5. A Large Volume Scattering Chamber for Angular Distribution Experiments.* J. RUSSELL, JR., C. W. REICH, AND G. C. PHILLIPS, *The Rice Institute.*—A large volume scattering chamber made of aluminum has been designed and constructed at The Rice Institute. It has an inside diameter of 30 inches and is 13 inches in height. To avoid alignment errors due to distortion of the evacuated chamber the detector slit system turntable and the beam defining slit assembly are rigidly supported independently of the chamber. The azimuth circle, complete with vernier, from a K and E transit, is used to measure angles accurate to one half minute of arc. The present particle detector is a potassium iodide crystal. The preamplifier and phototube are inside the chamber in a vacuum-tight cylinder which is open to atmospheric pressure. Provisions are made for both gas and solid targets. Details of construction and operation will be presented.

* Supported by U. S. Atomic Energy Commission.

C6. A Differential Pumping System for Gas Targets.* C. W. REICH, J. RUSSELL, AND G. C. PHILLIPS, *The Rice Institute.*—A differential pumping system to be used in connection with the large volume scattering chamber has been designed and built. Its construction and operation will be described. The pumping system has the form of a nozzle 36 in. long and 2¼ in. in diameter. Inside the tube there are 72 slits arranged in three groups which give the required pressure drops. The slits are made of brass sheet 10 mils thick. They are ⅜ in. in diameter and have a circular hole 2 mm in diameter. The pressures in the various regions, with 2 cm of air in the chamber are of the following magnitude: 550 microns after the first stage, 45 microns after the second stage, and 0.10 micron after the third stage. Pumping on the first stage is a roughing pump with a speed of 5 liters per second. Pumping on the second stage is a booster pump with a speed of 100 liters per second, backed by a mechanical fore pump with a speed of 1 liter per second. Pumping on the third stage which leads into the accelerator tube is the diffusion pump of the Van de Graaff. At either end of the system there are defining slits of Tantalum sheet, 10 mils thick. In each of these is drilled a hole 1.5 mm in diameter. With this system it is possible to admit the beam into the scattering chamber without its having to pass through a foil.

* Supported by the U. S. Atomic Energy Commission.

C7. Gamma-Rays from Ne^{22}.* B. P. FOSTER,† G. S. STANFORD, AND L. L. LEE, *Yale University.*—The decay scheme of the low-lying states of Ne^{22} has been investigated by means of a proton gamma-ray coincidence study of the $F^{19}(\alpha,p)Ne^{22}$ reaction using a NaI(Tl) scintillation spectrometer to measure the gamma-ray energies. The experimental arrangement was similar to that used in the previously reported investigation of Mg^{26}.[1] The energy of excitation of the second and third excited states were rechecked and found to be 3.3 and 4.9 Mev, respectively. The results of the study cast considerable doubt on the existence of the level at about 0.6-Mev excitation which had been previously reported. For the 1.28-Mev excited state a single transition direct to ground was identified. The second excited state was found to decay principally by the cascade transition through the first excited state with a weaker cross-over transition to ground. Transitions from the third excited state to the first excited state and to ground were established.

* Assisted by the joint program of the U. S. Office of Naval Research and U. S. Atomic Energy Commission.
† Now at North Texas State College, Denton, Texas.
[1] J. E. May and B. P. Foster, Phys. Rev. **90**, 243 (1953).

C8. Disintegration of La 140. C. L. PEACOCK, A. W. OSER, AND J. F. QUIN, *Tulane University.*—The radiations of La 140 have been investigated with a conventional magnetic spectrometer of 20-cm radius. The complex beta spectrum can be resolved into at least five groups whose maximum energies are: 0.83 Mev, 1.10 Mev, 1.34 Mev, 1.67 Mev, and 2.15 Mev. Most of the reported[1,2] gamma rays were verified. Those with energies of 0.110 Mev, 0.130 Mev, 0.240 Mev, 0.270 Mev, 0.328 Mev, 0.485 Mev, 0.815 Mev, and 1.60 Mev were found by photoelectric and internal conversion methods. A disintegration scheme will be proposed.

[1] Beach, Peacock, and Wilkinson, Phys. Rev. **76**, 1624 (1949).
[2] Cork, Stoddard, LeBlanc, Branyan, Martin, and Childs, Phys. Rev. **83**, 856 (1951).

FRIDAY AFTERNOON AT 2:00

Physics Building, Room 201

(F. A. MATSEN presiding)

Molecular Spectroscopy; Atomic Physics

D1. The Infrared Spectra of Deuterated Ethylene Oxide. CHARLES W. ARNOLD AND F. A. MATSEN, *The University of Texas.*—Fully deuterated ethylene oxide has been prepared and its infrared spectra studied over the range from 3 to 20 microns. The spectra have been carefully examined to allow for the presence of possible impurities. As far as possible, the bands have been assigned from their contours and relative intensities. The Teller-Redlich Product Rule has been used as an aid in locating weak bands and in confirming all final assignments. A normal coordinate treatment has been made for the molecule. By use of certain assigned bands from C_2H_4O and C_2D_4O, a set of force constants has been calculated and reasonable values predicted for some of the doubtful band frequencies. The calculated specific heat of the light molecule at 307.18°K based on this assignment is 11.817, which is to be compared with the experimental value of 11.80. The assignment of the infrared active bands of C_2D_4O is as follows: A_1—2211, 1311, 1015, 969, 753; B_1—2176, 1163(?), 905(?), 811; B_2—2316, 896, 578.

D2. Molecular Wavefunctions in the *e*-Notation. J. M. MILLER AND F. A. MATSEN, *University of Texas.*—The *e*-notation for determinants and the summation convention, both described by Craig,[1] are useful for writing electronic wavefunctions. For example a general N-electron molecular wavefunction may be written as follows:

$$\Psi = (1/N!^{\frac{1}{2}})e^{rstu\cdots xy\cdots}A_{ij,\,kl,\,\ldots}\phi_r{}^i\phi_s{}^j\phi_t{}^k\phi_u{}^l\cdots\phi_x{}^p\phi_y{}^q\cdots.$$

The sets $rstu\cdots xy\cdots$ index the N electrons. The sets ij, kl, $\cdots$ index atomic orbitals. The number of pairs of different indexes on A gives the number of bonds in the molecule. The range of indexes on A is determined as follows. Counting numbers are assigned to the atomic orbitals. The summations extend over the whole range of these numbers, except that A vanishes

when the same number is assigned to members of different pairs or if the interchanging of two or more pairs produces a previously obtained arrangement. Specific valence structures, ionic terms, or hybridization can be eliminated by suitable restrictions on the indexes. This notation reduces somewhat the amount of analytical work required to write down matrix elements.

[1] H. V. Craig, *Vector and Tensor Analysis* (McGraw-Hill Book Company, Inc., New York, 1943).

D3. The United Atom-Separated Atom Treatment of H_2^+. J. R. STREETMAN AND F. A. MATSEN, *University of Texas.*—Since H_2^+ at $r=0$ becomes He^+ and at $r=\infty$ becomes $H+H^+$, it might be expected that a linear combination of wavefunctions for each of these limiting forms would provide an improved description of the molecule ion. A trial wavefunction consisting of a linear combination of 1*S* orbitals centered on the nuclei and on a point halfway between them was used in a variational treatment. A one-electron three-center integral with nonequal charges which arises in this treatment was evaluated. The effective nuclear charges for minimum energy were found approximately by calculating energies for a range of values of the separated atom charge and of the united atom charge. The lowest energy calculated, −0.5969A, occurred where both effective nuclear charges are equal at 1.25. The energy value should be compared with −0.6031A, the exact value, and with −0.6001A obtained by hybridizing 1*S* and 2*Pz* orbitals on the separated nuclei. The mixing coefficient of the united atom was found to be 0.3501.

D4. Application of the Franck-Condon Principle to the Bent XY_2 Molecule.* J. B. COON AND J. K. WARD, *A and M College of Texas.*—A method is described for comparing the experimental intensities of vibronic bands of an XY_2 molecule with Condon overlap integrals calculated to the harmonic approximation. Using the vibrational frequencies and the apex angle for a given electronic state, normal coordinates Q_i may be calculated by known methods. Three independent Cartesian coordinates x_i of the nuclei for the ground electronic state are related to similar coordinates x_i' for the excited state by $x'=x+C$, where C is a three-element column matrix determined by the equilibrium bond distances and angles of both states. This leads to the relation $Q'=\zeta Q+K$, where ζ is a 3×3 matrix in which the elements ζ_{13}, $\zeta_{23}\neq0$ unless $\theta'=\theta$. The Condon overlap integral takes the form

$$I=N'(v_1'v_2'v_3')N(v_1v_2v_3)\int\int\int\Pi_i\, H_{v_i'}(\alpha_i'Q_i')\times\exp(-\tfrac{1}{2}\alpha_i'^2Q_i'^2)\Pi_j\, H_{v_j}(\alpha_jQ_j)\exp(-\tfrac{1}{2}\alpha_j^2Q_j^2)dQ_1dQ_2dQ_3,$$

where $\alpha_i^2=(4\pi^2/h)c\omega_i$, and $H_{v_i}(\alpha_iQ_i)$ are Hermite polynomials. This is easily evaluated for any special case. The ratio of the overlap integrals for two vibronic bands is known to be related to the integrated molecular extinction coefficients ϵ_i for these two bands by $(I_1/I_2)^2=\exp[hc(G_1-G_2)/kT](\nu_2/\nu_1)\times(\int\epsilon_1\delta\nu/\int\epsilon_2\delta\nu)$, where G_i is the ground state vibrational level associated with band i. Sufficient data are available for ClO_2 to evaluate these integrals.

* This research was supported by the U. S. Air Force through the Office of Scientific Research of the Air Research and Development Command.

D5. Vibrational Analysis of the 3400–4000A Absorption Spectrum of SO_2.* R. K. RUSSELL, *A and M College of Texas* (introduced by J. B. Coon).—The SO_2 spectrum is being investigated in the 3400–4000 A region. Wave numbers have been measured on spectrograms obtained with absorbing paths up to 18 meter-atmospheres. These wave numbers have been used in a preliminary analysis. Within an average deviation of about 2 cm^{-1}, 23 bands fit the formula $\nu=\nu_0+(G_0'-G_0'')$, where $\nu_0=25{,}776.0$ cm^{-1} and $G_0'(v_1',v_2',v_3')=938.3v_1'+362.8v_2'+1119.65v_3'-34.60v_1'^2-1.95v_2'^2-25.77v_3'^2+1.82v_1'^3-5.9v_1'v_2'-21.55v_1'v_3'-9.1v_2'v_3'$. Ground-state levels G_0'' given by Nielsen[1] were used. Previously, in a brief report, Metropolis and Beutler[2] assigned the $(0,0,0)'\leftarrow(0,0,0)''$ band and gave approximate values of ν_1' and ν_2' that are essentially in agreement with the above formula. The $G_0'(2,1,0)$ and the $G_0'(0,0,2)$ excited state vibrational levels appear to perturb each other, the shift being about 33 cm^{-1}. It is expected that spectrograms to be made with still longer absorbing paths will reveal more bands, thus providing additional data needed to confirm or improve the analysis.

* This research was supported by the U. S. Air Force, through the Office of Scientific Research of the Air Research and Development Command.

[1] Shelton, Nielsen, and Fletcher, Phys. Rev. **91**, 235 (1953).
[2] N. Metropolis and H. Beutler, Phys. Rev. **57**, 1078 (1940).

D6. Vibrational Spectra of Methyltrifluorosilane. R. L. COLLINS AND J. RUD NIELSEN, *University of Oklahoma.*—The infrared spectrum of gaseous H_3C-SiF_3 has been obtained in the region from 2.5–36μ with the aid of NaCl, KBr, and KRS-5 prisms. The Raman spectrum of liquid H_3C-SiF_3 has been photographed with a three-prism glass spectrograph of linear dispersion 15 A/mm at 4358 A, and qualitative polarization observations have been made. The eleven active fundamentals have been assigned, and a tentative value has been assigned to the inactive fundamental. A normal coordinate analysis has been made, and thermodynamic functions have been calculated for several temperatures.

D7. Vibrational Spectra of Cyclobutforene.* M. Z. EL-SABBAN AND J. RUD NIELSEN, *University of Oklahoma.*—The infrared spectrum of gaseous cyclobutforene has been obtained in the region from 2 to 38μ with the aid of LiF, NaCl, KBr, and KRS-5 prisms. The Raman spectrum of the liquid phase has been photographed with a three-prism glass spectrograph of linear dispersion 15 A/mm at 4358 A. With some uncertainties as to symmetry species, twenty-two of the twenty-four fundamental vibration frequencies have been assigned, and the spectra have been interpreted in detail.

* This work has been supported by the U. S. Atomic Energy Commission.

D8. Infrared and Raman Spectra of Fluorinated Ethanes. VIII. Pentafluoroethane.* J. RUD NIELSEN, H. H. CLAASSEN, AND NORMA B. MORAN, *University of Oklahoma and U. S. Naval Research Laboratory.*—The infrared absorption spectrum of gaseous CF_3CF_2H has been observed in the region from 2 to 38μ, and the spectrum of the liquid from 2 to 22μ, with the aid of LiF, NaCl, KBr, and KRS-5 prisms. The Raman spectrum of gaseous CF_3CF_2H has been photographed with a three-prism glass spectrograph of linear dispersion 15 A/mm at 4358 A. All but two of the fundamental vibration frequencies have been assigned, and the spectra have been interpreted in detail.

* This work has been supported by the U. S. Atomic Energy Commission.

D9. Density Effects in the Raman Spectrum of Ammonia.* C. A. PLINT, R. M. B. SMALL, AND H. L. WELSH, *University of Toronto.*—The Raman spectrum of ammonia as a high-pressure gas, liquid, solid, and aqueous solution are compared in the higher frequency region with the spectrum of the low-pressure gas. At gas pressures up to 80 atmos, no appreciable hindering of rotation is present; however, a weak satellite of the ν_1 band is an unexplained feature of the spectrum at high pressures. The spectrum of the liquid, solid, and aqueous solution can be explained without postulating dimerization: the three higher frequency maxima can be assigned unambiguously to the $2\nu_4$, ν_1, and ν_3 vibrations if it is assumed that the hindering of rotation is almost complete. The half-width of the ν_1 band increases and that of the ν_3 band decreases with decreasing temperature and increasing density. The behavior of the ν_1 band is probably due to coupling of the vibrating dipoles in pairs of molecules, and the behavior of the ν_3 band to increasing hindering of molecular rotation. The rotational fine

structure found by earlier workers for the aqueous solution could not be observed even at high dispersion.

* Supported in part by a grant from the National Research Council of Canada.

D10. Variational Wave Function for Sodium.* D. M. SMITH† AND E. L. SECREST,‡ *North Texas State College.*—A determinantal combination of one-electron wave functions[1,2] with variable parameters has been used to construct a variational wave function for the ground state of the neutral sodium atom. The resulting wave function gives a calculated ground-state energy of 325.84 atomic units compared to the experimental value of 324.63 atomic units.[3]

* This work was submitted by D. M. Smith in partial fulfillment of the requirements for the M.S. degree at North Texas State College and was supported financially by a Faculty Research Grant.
† Now at the U. S. Army Chemical Center.
‡ Now at Consolidated Vultee Aircraft Corporation, Fort Worth, Texas.
[1] Morse, Young, and Haurwitz, Physical Review **48**, 1948 (1935).
[2] W. E. Duncanson and C. A. Coulson, Proc. Roy. Soc. Edinburgh **62**, 37 (1944).
[3] R. F. Bacher and S. Goudsmit, *Atomic Energy States* (McGraw-Hill Book Company, Inc., New York, 1932).

FRIDAY EVENING AT 7:00

Driskill Hotel

(R. T. BIRGE presiding)

Banquet of the American Physical Society

After-dinner speaker: W. P. WEBB, *University of Texas.*

SATURDAY MORNING AT 9:30

Batts Auditorium

(T. W. BONNER presiding)

Invited Papers in Nuclear Physics

E1. Photoelectron Production by Polarized Gamma Rays. F. L. HEREFORD, *University of Virginia.* (30 min.)

E2. Equilibrium Charge-Exchange Ratios for Low-Energy Protons. J. A. PHILLIPS, *Los Alamos Scientific Laboratories.* (30 min.)

E3. Energy Loss of Protons and Deuterons in Gases. WARD WHALING, *California Institute of Technology.* (30 min.)

E4. Survey of Average Total Neutron Cross-Sections in the 3–12 Mev Region. NORRIS NERESON, *Los Alamos Scientific Laboratories.* (30 min.)

E5. The Diurnal Variation of Cosmic Radiation. M. S. VALLARTA, *University of Mexico.* (20 min.)

SATURDAY MORNING AT 9:30

Physics Building, Room 203

(C. M. CLASS presiding)

Nuclear Physics, II

F1. Excitation Function and Q-value for $C^{14}(d,p)C^{15}$.* JAMES A. RICKARD AND EMMETT L. HUDSPETH, *University of Texas.*—The excitation function for $C^{14}(d,p)C^{15}$ has been studied with deuterons of energy 0.6 to 3.0 Mev. The $BaCO_3$ target was enriched 18.6 percent in C^{14} and had a thickness of 124 $\mu g/cm^2$. A previously suspected resonance[1] was definitely established at 2.15 Mev, with a width of nearly 400 kev. Analysis of the excitation curve in the low-energy region (0.7 to 1.3 Mev) shows that its shape may be explained on the basis of elementary penetrability theory if one assumes a Q-value of approximately 0.15 Mev. A sudden rise in the excitation curve, beginning in the region near 1.6 Mev (excluding the resonance), may be ascribed to the increasing effectiveness of deuterons of orbital momentum unity; a spin value of C^{15} of 5/2 is suggested on this basis, in agreement with theortical predictions.[2]

* Assisted by the U. S. Atomic Energy Commission.
[1] Hudspeth, Swann, and Heydenburg, Phys. Rev. **80**, 643 (1950).
[2] D. R. Inglis, Revs. Modern Phys. **25**, 425 (1953).

F2. γ-ray Spectrum of C^{15} and γ rays from Proton Bombardment of C^{14}.* K. R. SPEARMAN, E. L. HUDSPETH, AND I. L. MORGAN, *University of Texas.*—The delayed γ radiation resulting from bombardment of C^{14} with 2-Mev deuterons has

been studied with a single crystal scintillation spectrometer. The 2.4-second activity is identical with the β decay of C^{15}. Pulse height analysis reveals a strong γ ray of energy approximately 5.3 Mev,[1] with evidence for very weak components of higher energies. A decay scheme for C^{15} will be proposed. We have also bombarded a target of $BaCO_3$ (18.6 percent enrichment in C^{14}) with protons and have observed γ-rays which apparently are formed by proton capture. A relatively strong γ-ray component of energy about 5 Mev was observed, with energies up to approximately 10 Mev also recorded but not well resolved in our present crystal. Evidence for resonances in a 44-kev target have been obtained in the bombarding region from 1 to 2 Mev.

* Assisted by the U. S. Air Force.

[1] Hudspeth, Rose, and Heydenburg, Phys. Rev. **85**, 742 (1952).

F3. Angular Distribution of D(d,n) Neutrons Scattered from C, Al, S, Fe, Cd, Cu, W, and Pb. R. N. Little, Jr., C. P. Cadenhead, B. P. Leonard, Jr., J. T. Prud'homme, L. D. Vincent, and J. E. Wills, *The University of Texas.*—The D(d,n) neutrons from a 100-kilovolt accelerator were scattered by ring scatterers of carbon, aluminum, sulfur, iron, cadmium, copper, tungsten (wolfram), and lead in a geometry similar to that described by Whitehead and Snowdon.[1] The detector used was a 2-in. right circular cylinder of terphenyl xylene scintillating solution on a 5819 photomultiplier tube. A pulse-height analysis using a single-channel analyzer was taken for some of the angular distributions to separate the elastically scattered neutrons from the inelastically scattered neutrons and accompanying decay gamma photons. For the diameter of the rings and the bombarding energy of 100 kilovolts the neutron energy is 2.8 Mev.

[1] W. D. Whitehead and S. C. Snowdon, Phys. Rev. **92**, 114–119 (1953).

F4. Search for the $Li^7(n,t)$ Reaction. H. E. Banta and R. L. Macklin, *Oak Ridge National Laboratory.*—The reaction $Li^7(n,t)\alpha+n$ (or He^5) has been detected using fission neutrons and polonium-beryllium neutrons, by measuring the tritium produced upon neutron activation. The fission-neutron activation was made inside a uranium sleeve in the ORNL graphite pile, using cadmium and boron for additional shielding. Samples of natural and enriched Li^7F were used to allow for the tritium produced from Li^6. The computed threshold for the reaction $Li^7(n,t)\alpha+n$ is 2.8 Mev. The neutron population decreases exponentially above this energy; thus the measured cross section of 72 ± 18 mb is essentially that near 3 Mev. The polonium-beryllium neutron activation was carried out with source and samples suspended on a steel wire, 5 meters from possible neutron moderating structures. The cross section for the total flux (broad maximum near 4.5 Mev) was 30 ± 20 mb. The tritium was recovered by fusing the samples in 1-percent hydrogen-argon and its activity observed in a proportional counter. The tritium recovery and counting technique is to be described in a forthcoming paper on the $Li^7(d,t)Li^6$ reaction. This investigation is to be reported in a forthcoming article in Science.

F5. Neutron Thresholds from $Cu^{65}(p,n)Zn^{65}$, $Cu^{63}(p,n)Zn^{63}$, and $Li^7(p,n)Be^7$.* C. F. Cook and T. W. Bonner, *The Rice Institute.*—A new technique for detecting neutron thresholds using a slow neutron counter and a conventional long counter is discussed. This method has been applied to the bombardment of copper by protons. Many resonances in neutron emission were observed and neutron thresholds were found at 2.15, 3.03, and 4.28 Mev. The first two thresholds are due to Cu^{65} and indicate an excited state in Zn^{65} at 0.86 Mev. The 4.28-Mev threshold is due to Cu^{63}.

* Assisted by the U. S. Atomic Energy Commission.

F6. Neutron Thresholds in the Reactions $Li^7(d,n)^*Be^8$ and $Be^9(d,n)^*B^{10}$. T. W. Bonner and C. F. Cook, *The Rice Institute.*—Neutron thresholds from the deuteron bombardment of Li^7 have been studied at energies from 0.4 Mev to 4.7 Mev. Thresholds were observed at energies of 2.18 Mev, 2.55 Mev, 3.37 Mev, and 4.07 Mev. These thresholds indicate a level in Be^8 at 16.70 Mev with a half-width of 195 kev, a level at 16.99 Mev with a width of 350 kev, a narrow level at 17.63 Mev, and a wide level at 18.14 Mev. By the same method, excited states in B^{10} from the $Be^9(d,n)B^{10}$ reaction were found at 4.78, 5.11, 5.17, 5.93, 6.04, 6.16, and 6.61 Mev.

* Assisted by the U. S. Atomic Energy Commission.

F7. Neutrons from Proton Bombardment of Be^9 and H^3.* J. B. Marion, C. F. Cook, and T. W. Bonner, *The Rice Institute.*—The two-counter technique, described in the two preceding papers, has been applied to a study of the neutrons from the proton bombardment of Be^9 and H^3. A narrow excited state of B^9 has been observed at 2.36 Mev by neutron threshold measurements ($Q=-4.21$ Mev). This state corresponds to the 2.43-Mev level in the mirror nucleus, Be^9. In addition, threshold neutrons have been observed which may be due to a broad ($\sim$1 Mev) level in B^9 at $\sim$1.4 Mev. The $H^3(pn)He^3$ reaction shows only the single well-known threshold at $E_p=1020$ kev.

* Assisted by the U. S. Atomic Energy Commission.

F8. $N^{14}(n,2n)N^{13}$ Cross-Section Measurement with 14 Mev Neutrons.* J. D. Dudley and C. M. Class, *The Rice Institute.*—The $N^{14}(n,2n)N^{13}$ cross section was measured for 14-Mev neutrons obtained from the $T(d,n)He^4$ reaction. A liquid nitrogen sample was contained in a hemispherical Lucite vessel half enclosing a tritium-zirconium target. This arrangement maximizes the effectiveness of the neutron flux and simplifies the calculations for the cross section. For the purpose of preventing evaporation of the sample, the assembly was surrounded by a bath of liquid nitrogen. After irradiation, the sample was transferred to a Dewar flask of dimensions appropriate for efficient coincidence counting of the annihilation radiation from the 10 minutes positron activity of the N^{13}. The counting system was calibrated with a standardized solution of Na^{22}. The neutron monitor was calibrated by counting the α particles from the $T^3(d,n)He^4$ reaction. Preliminary measurements yield a cross section for nitrogen of 3.4 mb$\pm$30 percent. The method was also applied to other elements which were available in suitable liquid form.

* Supported in part by the U. S. Atomic Energy Commission.

F9. Nuclear Energy Levels by Absolute Magnetic Analysis of Inelastically Scattered Protons.* C. R. Gossett, G. C. Phillips, and J. T. Eisinger, *The Rice Institute.*—The Rice Institute annular magnet has been used to measure the energies of protons scattered at 180° from thin targets. Energies of the elastic and inelastic scattered protons are determined from their $B\rho$ as measured in terms of standardized length and frequency. The energy measurements are sufficiently accurate to permit calculation of the mass number of the scattering nuclei when two different bombarding energies are used. This method offers the advantages of absolute measurement, high resolution, high accuracy, and positive identification of the scattering nuclei. The apparatus and techniques will be described and the results of experiments on F^{19} given.

* Supported by the U. S. Atomic Energy Commission.

F10. Nonelastic Scattering of Fast Neutrons.* H. L. Taylor, O. Lönsjö, and T. W. Bonner, *The Rice Institute.*—Nonelastic scattering cross sections have been obtained using the spherical shell method. The neutron detectors were made of small anthracene spheres embedded in CF_2 liquid. These

give good energy discrimination and do not count γ radiation. Results have been obtained with monoenergetic neutrons with energies of 4.5, 7.0, and 14.1 Mev, in Ti, Cr, Fe, Ni, Cu, Ag, Sn, Pb, and Bi. At these energies the nonelastic cross sections is geometrical and can be explained by the relation $\sigma=\pi(R+\lambda\!\!\!^{-})^2$.

* Assisted by the U. S. Atomic Energy Commission.

F11. A Fast Neutron Counter with Energy Resolution.* J. H. McCRARY, H. L. TAYLOR, AND T. W. BONNER, *The Rice Institute.*—Fast neutron counters have been made of small spheres of anthracene separated from each other by either CF_2 liquid or glass. Recoil proton pulses from 3–20 Mev neutrons can be made larger than γ-ray pulses by using spheres with diameters of from 3 to 8 mm. Several millimeters of glass between the spheres prevent electrons from going through two or more anthracene crystals. Neutron energies can be obtained from the maximum pulse size.

* Assisted by the U. S. Atomic Energy Commission.

F12. LiI(Eu) Crystals as Neutron Detectors.* J. B. MARION, *The Rice Institute.*—Distributions of pulse heights produced by monoenergetic neutrons in europium-activated LiI crystals have been taken, using neutrons from the reactions $H^3(p,n)He^3$ and $Be^9(d,n)B^{10}$. In the former case, with 1200-kev neutrons, a pulse height four times that of Cs^{137} gamma rays was observed, with a resolution of 20 percent. However, with neutrons from $Be^9(d,n)B^{10}$, the peak could not be resoived because of the strong gamma-ray background present. It appears that LiI crystals will be useful for detecting neutrons only under conditions of low gamma-ray background.

* Assisted by the U. S. Atomic Energy Commission.

SATURDAY MORNING AT 9.30

Physics Building, Room 201

(J. H. CRAWFORD presiding)

Solid-state Physics; Cryogenics

G1. The Variation Method Applied to Wave Functions in Crystals. W. V. HOUSTON, *The Rice Institute.*—Although the variation method has been widely applied to wave functions for atoms and molecules, it has been used only recently for crystals. The wave function in a periodic potential consists of a plane wave modulated by a function with the period of the lattice. The variation method can be applied to the modulation function by expanding it in a Fourier series with the vectors of the reciprocal lattice. The coefficients of the expansion can then be determined to give the energy a stationary value. The process can be carried as far as desired, but it seems probable that a relatively small number of terms will give good indications of the dependence of the energy on the propagation vector. It is also probable, however, that a small number of terms will not give good values for the wave function in the neighborhood of the atomic core.

G2. Electron Interactions in Metals. ROBERT L. CHUOKE, *The Rice Institute** (introduced by C. H. Fay).—A modification of Macke's variational calculation of correlation energy[1] for conduction electrons in metals yields a correlation energy still in essential agreement with Wigner's early result while providing a screening function $\beta=\beta(g)$, depending only on the magnitude g of momentum change, which is also applicable to screened Coulomb perturbation matrix elements associated with energy conservative transitions such as occur in Landsberg's calculation of the L_{III} soft x-ray emission spectrum of sodium.[2] For small g, which is the important range with regard to divergences, $\beta^2(g)=\kappa k_F^2+0(g)$ where k_F is the Fermi level and $\kappa=(2/\pi)(4/9\pi)^{\frac{1}{3}}(\rho_s/a_H)$, a_H = Bohr radius, and $4\pi\rho_s^3/3=V/N$, volume per conduction electron. For sodium, neglecting terms of order g, $\beta=10^8$ cm^{-1} which agrees with the empirical value.[3] The result predicts increasing tail lengths of soft x-ray emission spectra for increasing density of conduction electrons. It should be noted that in this approach to electron interactions the insertion of a screened potential into the exchange integral, as was done by Wohlfarth,[4] does not seem to be justified.

* Now with Shell Development Company, Houston, Texas.
[1] W. Macke, Z. Naturforsch. **5A**, 192 (1950).
[2] P. T. Landsberg, Proc. Phys. Soc. (London) **62**, 806 (1949); H. W. B. Skinner, Phil. Trans. Roy. Soc. **A239**, 95 (1946).
[3] E. P. Wohlfarth, Phil. Mag. **41**, 534 (1950). See also D. Bohm and D. Pines, Phys. Rev. **80**, 903 (1950) as well as their more recent work.

G3. Field Dependent Magnetic Susceptibility of MnSe. ROBERT LINDSAY, *Southern Methodist University.*—A further analysis has been made of the data originally reported by the writer.[1] Comparison is made with the results obtained by other investigators. A theory is advanced to explain the observed field dependent susceptibility effects in terms of a feeble parasitic ferromagnetism. When the data are interpreted on this basis, magnetization curves can be drawn which show the parasitic ferromagnetism starting at about 10°C, increasing to a maximum at about −120°C, and decreasing to a small but finite value at −190°C. The magnitude of the ferromagnetism appears to depend on the thermal history of the sample and follows a hysteresis pattern similar to that for the susceptibility. The results are discussed in terms of the three phase model for MnSe proposed by the writer.[1]

[1] R. Lindsay, Phys. Rev. **84**, 569 (1951).

G4. Some Electrical Characteristics of Polycrystalline Boron.* L. J. BADAR AND V. P. JACOBSMEYER, *Saint Louis University.*—The properties of high purity boron samples deposited at 1000°C, 1300°C, and 1500°C by the pyrolytic decomposition of diborane gas were compared with results obtained by Friedrich.[1] Sample micrographs and x-ray diffraction patterns revealed large size crystallites in samples deposited at 1000°C and 1500°C, while 1300°C samples exhibited a fine grain structure. From a room-temperature value of 2700 ohm-cm, the resistivity dropped to less than 10 ohm-cm at 640°K in the 1300°C samples. A decrease in resistivity by a factor of 20 in the 1000°C samples was noted over the same temperature range. A small but definite increase in slope of the $\log\rho$ *vs* $1/T$ curves was observed for all samples at about 450°K. For the 1000°C samples the activation energy measured 0.30 ev, while a value of 0.86 ev was obtained from data on the 1300°C samples. X-rays were found to have little effect on the resistivity at high temperatures, indicating that the low-temperature resistivity change induced by the x-ray bombardment was caused by the impurities present. Activation energy values were not altered by the irradiation.

* Research carried out under contract with U. S. Office of Ordnance Research.
[1] L. W. Friedrich and V. P. Jacobsmeyer, Phys. Rev. **91**, 492(A) (1953).

G5. The Electrical Properties of Molybdenite. C. W. HEAPS, *Rice Institute.*—The resistance, magnetoresistance, and Hall effect have been measured for natural crystals of molybdenite at different temperatures. The material was an *n*-type semiconductor. The resistivity is 1.6 ohm-cm at 26°C and about 30 000 times larger at −190°C. The Hall constant is independent of magnetic field strength up to 7000 gauss. It is equal to 1260 (in e.m.u.) at room temperature and 27 000 at −76°C. Magnetoresistance is small—a resistance increase of about 0.015 percent for a magnetic field of 20 000 gauss at room temperature. There is evidence of an internal barrier layer effect which is associated with the foliated character of the crystal structure.

G6. The Time Rate of Change for the Transformation of Monoclinic Selenium into Hexagonal ALVIN E. COWAN* AND ARTHUR E. LOCKENVITZ, *University of Texas.*—Finely divided monoclinic crystals of selenium were placed in a constant temperature over x-ray diffraction apparatus. A Geiger counter feeding into a recording rate meter was set at the angle to receive a prominent line diffracted from any hexagonal selenium present. The intensity of this line was used as a measure of the amount of hexagonal selenium present and of the disappearance of the monoclinic modification. The temperature region from 70°C to 120°C was explored.

* At present at Pentagon, U. S. Army.

G7. Flow of Helium II Under a Hydrostatic Pressure Head.* R. T. SWIM† AND H. E. RORSCHACH, JR., *The Rice Institute.*—The pressure induced isothermal flow properties of HeII have been studied with an arrangement similar to that of Bowers and Mendelssohn.[1] Measurements of the flow rate have been made with hydrostatic pressures up to 2.3×10^3 dynes/cm^2 at temperatures between 1.39 and 2.10°K. Slit widths of 4.3 and 2.4 microns were used. At low pressures, the flow rate is proportional to approximately the $\frac{1}{3}$ power of the pressure head, although this power depends on the slit width. At higher pressures, the flow rate is independent of the pressure head. This saturation rate corresponds to a maximum velocity for the superfluid component of approximately 22 cm/sec. The flow rates at constant pressure head have the same temperature dependence as the superfluid concentration in liquid helium II. The significance of these flow measurements in interpreting the hydrodynamic properties of helium II will be discussed.

* This work supported in part by the U. S. Office of Naval Research.
† Magnolia Petroleum Company Fellow at Rice Institute (1952–1953). Now at the Bell Telephone Laboratories, Murray Hill, New Jersey.
[1] R. Bowers and K. Mendelssohn, Proc. Roy. Soc. (London) **A218**, 158 (1952).

G8. The Decay of Positrons in Superconducting Lead.* WALTER E. MILLETT, *University of Texas.*—The decay of positrons in superconducting lead has been studied by the method of delayed coincidences. A block of lead of questionable purity containing a sodium-22 source of positrons was fastened to a metal flask containing liquid helium at atmospheric pressure. The lead was then well below its transition temperature. A delay coincidence curve was measured with liquid helium in the flask and then measured again with liquid nitrogen in the flask. The measurements indicate that the mean life of some of the positrons in superconducting lead is increased to (3.5±0.5) millimicroseconds. The measurements of Bell and Graham[1] show that all positrons decay in lead at room temperature with a mean life (0.15±0.06) millimicrosecond. This work is being continued at the University of Texas with improved resolution and with different superconductors.

* This work was carried out during the past summer at the Cyclotron Laboratory of Harvard University. The liquid helium was supplied by both Harvard University and Massachusetts Institute of Technology.
[1] R. E. Bell and R. L. Graham, Phys. Rev. **90**, 644 (1953).

G9. Lifetime of Positrons in Superconductors. HARRY TALLEY AND ROBERT STUMP, *University of Kansas.*—The lifetime of positrons in solids is considerably different for metals and insulators. Since a metal in the transition to the superconducting state undergoes marked changes in electrical conductivity as well as other properties depending on the electron interactions, it was thought that the lifetime of positrons in superconductors might indicate something of the nature of the superconducting state. Using the method of delayed coincidence, we have measured the lifetime of positrons from Na^{22} enclosed in a lead cylinder at a temperature of 4.2°K. The experiment indicates that the lifetime of the positrons in the superconducting lead is longer than the lifetime of positrons in the same sample in the normal state. The results are in qualitative agreement with theoretical estimates of the expected change in lifetime based on the Frohlich theory of superconductivity.

SATURDAY AFTERNOON AT 1:30

Batts Auditorium

(R. T. BIRGE presiding)

Invited Paper

H1. Coulomb Excitation of Nuclei. C. M. CLASS, *Rice Institute.* (30 min.

Nuclear Physics, III

H2. Coulomb Excitation of Heavy Nuclei.* C. M. CLASS, C. F. COOK, AND J. T. EISINGER, *The Rice Institute.*—A gold target of the highest purity available commercially has been bombarded with 3-Mev protons. Gamma radiation was observed with a NaI crystal spectrometer of good resolution which fits the known low-energy level scheme of Au^{197}. While these gamma rays are believed to be due to the Coulomb excitation[1] of the gold, the possibility that they were due to target contaminants is not excluded and is being investigated. The magic nuclei bismuth and lead were studied similarly and no radiation ascribable to nuclear excitation was observed. The spectra of various other heavy elements will be shown. Yield curves and angular distributions will be presented where obtained and compared to existing theory.

* Assisted by the U. S. Atomic Energy Commission.
[1] T. Huus and Č. Zupančič, Kgl. Danske Videnskab. Selskab, Mat.-fys. Medd. **28**, No. 1 (1953); C. McClelland and C. Goodman, Phys. Rev. **91**, 760 (1953).

H3. Sea-Level Zenith-Angle Dependence of High-Energy Mu-Mesons. N. M. DULLER,* W. D. WALKER,† J. W. GRAHAM,‡ AND J. R. RISSER, *Rice Institute.*—Preliminary experiments with counter telescopes, lead absorber, and soft shower detectors will be described. Results appear to indicate a broad maximum near 20° zenith angle in the intensity of high-energy mu-mesons. In one experiment a six-fold coincidence was required between two counter telescope elements and four individual counters below four inches of Pb. The four Pb-shielded counters were used to detect soft showers caused by bremsstrahlung and knock-on electrons from mu-meson interactions in the Pb. This shower detector was also shielded below by four inches of Pb. Counters placed beneath the lower shield were used to rule out penetrating showers. In another experiment a large proportional counter was used in place of the four Geiger counters. Counting rates were recorded as a function of zenith angle and integral pulse height. The zenith-angle variation measured for large pulses agrees qualitatively with results of the Geiger counter experiment. Some of the data are difficult to interpret in terms of decay-absorption competition of pi-mesons.

* Now at Texas A. & M. College, College Station, Texas.
† Now at University of Rochester, Rochester, New York.
‡ Now with Humble Oil & Refining Company, Houston, Texas.

H4. An Improved Spark Counter for Detecting Alpha Radiation. CHARLES E. WELLER, *University of Texas* (introduced by R. N. Little, Jr.).—A multiple-wire counter which utilizes spark discharges for the detection of heavily ionizing nuclear radiations was designed and a careful study of its properties was made. Although the counter was tested for alpha particles emitted by Po^{210} nuclei, there is a possibility that with some modifications the spark counter could be adapted for the detection of fission fragments also. The counter is definitely insensitive to all electromagnetic radiations, including high-energy gamma rays. The apparatus works in ordinary air, and it distinguishes itself by its large output pulse, low background counting rate, and high efficiency. About 56 percent counting efficiency was attained by a novel arrangement of the electrodes. This corresponds to a counting of approximately 96 percent of all the particles which pass between the electrodes. The long plateau of the counting characteristic, extending over a thousand volts, eliminates the need for a regulated power supply.

H5. Coincidences in the Scintillation Counter. A. L. ORVIS AND M. M. D. WILLIAMS, *Mayo Clinic and Mayo Foundation.*—Certain applications of the scintillation counter, such as its use for measuring high levels of activity or the simultaneous counting of two different gamma emitters, may require counting with high discriminator bias. Coincident events cause a release of energy in the scintillator which is the sum of the energies released by the individual events. Thus some pulses which would fall below the discriminator level may be augmented by coincident pulses and counted. The contribution of these augmented pulses to the counting rate is a function of the form of the pulse height spectrum and of the discriminator setting, and is not linearly related to the source strength. An expression relating the count due to coincident pulses to the appropriate variables will be presented and applied to the problem of counting only the 0.637- and 0.722-Mev photons from I^{131}.

H6. Range and Charge of Energetic Nitrogen Ions in Nickel. D. W. SCOTT, H. L. REYNOLDS, AND A. ZUCKER, *Oak Ridge National Laboratory.*—Thin nickel foils, varying from 0.5 to 8 mg/cm² thickness, were bombarded with the deflected beam of N^{3+} ions accelerated by the ORNL 63-inch cyclotron. After passing through the foils the nitrogen ions entered a shallow gas chamber filled with hydrogen at approximately 3-cm Hg pressure. Elastically scattered protons emerged from the chamber through a thin window at zero degrees and were counted with a proportional counter. The energy of the recoil protons was measured by absorption in aluminum foils, which in turn gave the energy of nitrogen ions entering the gas chamber. In another experiment energetic nitrogen ions were passed through thin nickel absorbers and collected in a Faraday cup. Making sure that cyclotron conditions do not vary during a run, the average charge of nitrogen ions as a function of absorber thickness was measured relative to the three-times-charged unattenuated beam. The experimental arrangement will be described, and comparison with theory will be made for range-energy relations and charge-velocity relations of nitrogen ions in nickel.

H7. Analyzing Magnet for a 100Kv Modified Cockcroft-Walton Accelerator. JAMES E. WILLS AND HENRY R. DVORAK,* *The University of Texas.*—Grid-controlled thyratrons were used to provide constant current to the coil of a magnet that will deflect a 100 kv beam of ionized deuterium or tritium 90 degrees in a 20-centimeter radius. The control circuit is similar to a simple error system used in servomechanism systems.

* Now at Convair, Fort Worth, Texas.

H8. NaI Gamma-Ray Spectrometry Techniques Applied to the Outlining of Brain Tumors. J. R. RISSER, *The Rice Institute,* AND H. C. ALLEN, JR., *V. A. Hospital Radioisotope Unit, Houston.*—Iodinated human serum albumen with tracer I^{131} is injected in the patient in the usual manner. The detector consists of a sodium iodide crystal, photomultiplier tube, pulse amplifier, and single channel differential pulse-height analyzer as in the standard NaI gamma-ray spectrometer. The combination is set to respond only to the 364-kev component of the I^{131} radiation. This selective response allows the elimination of gamma rays diffusely scattered by the Compton process and increases by at least a factor two the ratio to background of the significant count due to the tumor. By retracting the NaI crystal well back into a lead shield with a small opening, the counter is made to respond to the activity of a small conical section of tissue. The scan is automatic in a plane tangent to the head. Successful outlines of radioactive concentrations in phantoms and of tumors in living patients have been obtained.

SATURDAY AFTERNOON AT 1:30

Physics Building, Room 201

(A. W. NOLLE presiding)

Magnetic Resonance

I1. Analysis of Phase Detectors for the Display of Nuclear Magnetic Resonance Signals.* WILLIAM L. ROLLWITZ, *Southwest Research Institute.*—This paper presents a mathematical and experimental analysis of 4 phase detectors for the display of nuclear magnetic resonance signals. The circuits are analyzed as to their stability, linearity, sensitivity to phase and

amplitude changes of the reference, and "carrier leak balance." Several graphs and pictures are displayed to show the results and conclusions of the analysis.

* Supported by the Corn Industries Research Foundation.

I2. Nuclear Resonance Absorption in Weak, Homogeneous Fields.* R. W. MITCHELL AND MELVIN EISNER, *Texas A and M College.*—Very stable homogeneous magnetic fields have been obtained using a compensated solenoid powered by lead storage cells. The homogeneity, as indicated by the line width of distilled water, is 0.1 milligauss at 40 gauss field strength, for a sample size of 50 cc. To obtain this homogeneity permanent magnet shims have been used to reduce the effect of the inhomogeneity in the Earth's magnetic field. Slow sweep techniques are used to obtain the steady state resonance conditions and to prevent the occurrence of transients. The over-all stability of the equipment is sufficient to allow sweep rates as slow as 0.05 milligauss per second to be used. Some results obtained with this equipment will be discussed.

* Supported in part by the U. S. Office of Ordnance Research.

I3. A Narrow Gap Electromagnet for High Resolution Nuclear Resonance Spectrometry.* ALVIN F. HILDEBRANDT, *Texas A and M College.*—The homogeneity of the magnetic field produced by a narrow gap electromagnet has been studied using the nuclear resonance fine structure pattern of ethyl alcohol. Five-inch diameter pole faces were used to produce a 5000-gauss field in a $\frac{3}{4}$-inch gap. The pole caps were annealed and then polished to an optical flat. The signal strength and resolution were measured for different positions in the field for various sample sizes. While the fine structure could be resolved in samples as large as 125 mm^3, the improvement in resolution for sample sizes down to 6 mm^3 was not as good as would be expected for a uniform gradient inhomogeneity. The magnetic structure of the pole cap material introduces a randomly distributed inhomogeneity although isolated regions can be found which have a favorable homogeneity.

* Supported in part by the Texas Petroleum Research Committee.

I4. Paramagnetic Resonance Absorption in Diphenyl Picryl Hydrazyl at Low Values of Splitting Field. STEWART BECKER* AND MELVIN EISNER, *Texas A and M College.*—Paramagnetic resonance absorption has been observed in diphenyl picryl hydrazyl at fields of 10, 2.5, and 0.7 gauss. The line width as measured by the change in field between maximum slope points of the absorption signal was 1.25 and 1.12 gauss at fields of 10 and 2.5 gauss, respectively. Below 3 megacycles the situation is complicated since the splitting field is less than the line width. The spectral line in this region consists of contributions from both circularly polarized components of the rf field. At 2 megacycles the line width as measured by contributions from a single direction of circular polarization is 1.16 gauss and as measured by contributions from both is 0.78 gauss.

* On leave from the University of Arizona.

Post-Deadline Papers, if Any

SATURDAY AFTERNOON AT 1:30

Physics Building, Room 203

(N. D. SMITH presiding)

General Physics

J1. A Mechanical Electric Computer for Solving Polynomial Equations. HARRY J. AUVERMAN AND ARTHUR E. LOCKENVITZ, *University of Texas.*—A computer using rotating slider type variable autotransformers and sine and cosine resolvers along with a cathode-ray oscilloscope is used for obtaining the real and complex roots of a polynomial equation with real coefficients. The equation of the form

$$A+ax+bx^2+\cdots=0$$

is first transformed into

$$A+aM\cos\theta+bM^2\cos 2\theta+\cdots aM\sin\theta+bM^2\sin 2\theta+\cdots=0.$$

The M's are obtained from the autotransformers mounted on a common shaft, the coefficients A, a, b, etc., from individual autotransformers. The cosine and sine terms are generated by ac-type sine and cosine resolvers. The output of the cosine series is applied to one set of oscilloscope plates and the sum of the sine series to the other set of plates. The θ's and M's are then adjusted until zero deflection is indicated on the oscilloscope.

J2. Accurate Determination of The Tidal Variations of Gravity. HENRY NEAL CLARKSON AND ARTHUR E. LOCKENVITZ, *University of Texas.*—Using a modified La Coste-Romberg Gravity meter, continuous readings of the gravitational fields at Austin, Texas were made over a period of two months. These readings were compared with calculated gravitational field variations due to the positions of the sun and moon on the assumption that the earth is a rigid body. The differences between the observed values and the calculated values were compared to the calculated values as peak to peak amplitude ratios. An average value of 0.295 for the ratio of major peaks and 0.33 for the minor peaks ratio was found. There was no appreciable shift in phase between the difference curve and the calculated curve. The accuracy of the readings and calculations was better than one microgal. A detailed discussion of the results will be made.

J3. Shock Hugoniot of Air. W. E. DEAL, JR., *Los Alamos Scientific Laboratory.*—Gaseous shocks are created by the use of explosive-driven metal plates. An optical technique using the Schlieren principle in conjunction with a high-speed framing camera is employed for the simultaneous measurement of shock velocity and the difference between plate and shock velocities. A series of experiments with varying plate velocities yield data which allow derivation of the pressure-compression curve by use of the mass and momentum conservation equations. Since the difference between particle and shock velocities appears in the compression expression and is also small compared to either velocity, direct measurement of the difference is an advantage of this method. The velocities are measured with precisions of the order of 2 percent. The method

permits measurements for shocks in the pressure region from 10 to 500 atmospheres. Specific data are reported for air and compared to theoretical predictions.

J4. The Effect of Hydrostatic Pressure in the Two-State Model of Compressional Relaxation in Liquids. A. W. NOLLE, *The University of Texas.*—It was shown by Hall[1] that compressional energy losses in water, as determined from ultrasonic absorption data, can be related to a model in which rearrangement occurs at a finite rate between two states of local order characterized by different specific volumes. The higher free energy was attributed to the more condensed state, but it was recognized that a revised interpretation might be required for nonassociated liquids. It is shown in the present analysis that this interpretation of the two-state model predicts that the compressional losses will always increase with hydrostatic pressure. On the other hand, if the higher free energy is attributed to the less condensed state (which is consistent with the view that this is a "hole"), it is then possible for compressional losses to decrease with increasing hydrostatic pressure. Thus, experimental information concerning the pressure dependence of compressional losses can aid in distinguishing between these versions of the two-state model.

[1] L. Hall, Phys. Rev. **73**, 775 (1948).

J5. Absorption of Ultrasonic Waves in Liquids under Pressure. J. F. MIFSUD, *The University of Texas.*—A pulse-reflection technique is employed to measure the absorption of ultrasonic waves in liquids under pressure in the range up to 1400 atmospheres. The absorption, and also the wave velocity, are obtained through a comparison of the amplitudes and arrival times of two reflected signals, initiated by the same source, but traversing paths of different length. The work is intended to provide further information regarding the absorption process in those liquids in which there is evidence of large compressional relaxation effects. Results are presented for carbon tetrachloride at a frequency of 5 mc. The absorption per wavelength decreases continuously with increasing pressure. This result is consistent with a picture of the compressional absorption process based on the hole theory of liquids.

J6. The Compressibility of Liquid Cholesterol Benzoate at the Isotropic-Anisotropic Transition. W. A. HOYER, *The University of Texas.*—On heating, cholesterol benzoate melts to form an anisotropic liquid, sometimes referred to as a "liquid crystal" phase. At a higher temperature there is a sharp transition to an isotropic liquid state. This transition is investigated in terms of the velocity and absorption of ultrasonic waves. The measurements are performed with a pulse-reflection technique. From the velocity measurements and from available density data, it is found that the compressibility has a sharp maximum at the transition. Also, there is a strong maximum in the absorption of ultrasonic waves near the transition. A portion of the apparent absorption actually represents scattering, which substantially restricts measurements to frequencies of the order of 1000 kc and less.

J7. Transmission of Pulses through an Elastic Plate. ARTHUR S. GINZBARG AND WILLIAM L. ROEVER, *Shell Development Company.*—It will be shown that if an elastic plate is submerged in an elastic liquid and both the pulsed point source of pressure and the point pressure detector are on the same normal to the plate, then the pressure at the detector will contain arrivals corresponding to multiply-reflected rotational as well as compressional waves in the plate.

J8. Thickness of Films Left on Capillary Wall During Displacement of One Fluid by Another. CHARLES C. TEMPLETON, *Shell Development Company* (introduced by C. H. Fay).—Techniques were devised to observe displacement of one fluid by another immiscible fluid in uniform microscopic capillaries.[1] From interfacial velocity for a constant pressure difference across the capillary, one can calculate an effective viscosity for each phase assuming that Poiseuille flow prevails, that displacement is perfect, and that static and dynamic capillary pressures are equal. Measurements were made for oil-water displacements (interfacial velocities = 1 cm/min) in capillaries initially filled with water, in which case the assumed absence of capillary pressure hysteresis appears adequate. When the oil viscosity is about one poise or more, the effective oil viscosity becomes about one-half the normal value. Assuming the absence of perfect displacement and the existence of an annular water film around the oil, film thicknesses between 20 and 100A can be calculated. By other methods it was shown that an oil film about 100A thick is left when air displaces oil.

[1] C. C. Templeton, Paper 307-G, Petroleum Branch, Am. Inst. Mining Met. Engrs. (October, 1953).

J9. Diffraction Measurements at 1.25 Centimeters. C. W. HORTON AND W. W. GRANNEMANN,* *The University of Texas.*—A series of measurements were made of the diffraction of essentially plane electromagnetic waves by conducting metallic objects. The objects studied were circular disks, circular rods, and parallel semi-infinite plates, and the dimensions were chosen to be neither large nor small compared to a wave length. The experimental techniques used were very similar to those described by Horton and Watson[1] except that in the present instance the wavelength was 1.25 centimeters. An attempt was made to select configurations of scattering objects which would be suitable for checking the formulas developed in the past few years by Bouwkamp, Clemmow, Copson, Heins, Twersky, and others. A representative set of diffraction patterns will be shown and discussed. Comparison with theory will be given for several examples.

* Now at the California Research Corporation, La Habra, California.
[1] C. W. Horton and R. B. Watson, J. Appl. Phys. **21**, 16 (1950).

J10. Diffraction of Electromagnetic Waves by a Metallic Wedge of Acute Dihedral Angle. W. W. GRANNEMANN,* C. W. HORTON, AND R. B. WATSON, *The University of Texas.*—In the rigorous theory of diffraction by a conducting wedge as developed by Sommerfeld and extended by Pauli,[1] the total field is represented by the terms given by geometrical optics plus a contour integral which represents the diffracted waves. If the faces of the wedge form a dihedral angle of π/n, $n=1, 2, 3, \cdots$, the contour integral vanishes identically and the solution given by geometrical optics is exact. This prediction has been tested and checked by measurements of the diffraction patterns of wedges whose dihedral angles were 90°, 60°, and 30°. The measurements were made at a wavelength of 1.25 centimeters and the source was far enough so that the incident wave was essentially plane.

* Now at the California Research Corporation, La Habra, California.
[1] W. Pauli, Phys. Rev. **54**, 924 (1938).

J11. The Study of Electrokinetic Relations Using Sinusoidal Pressure and Voltage.* CLAUDE E. COOKE, *The University of Texas.*—The method previously described by Packard[1] for measuring streaming potentials across porous diaphragms for sinusoidal flow has been used to study the general electrokinetic relations derived from the equations[2]

$$I = C_{11}E + C_{12}P,$$
$$V = C_{21}E + C_{22}P.$$

I and V are electric current and volume flow rate, and E and P are the electric potential difference and pressure difference across a porous medium. Fritted glass diaphragms saturated

with distilled water have been used. The range of pressures is from 0 to 10 000 dynes per cm² (rms) and the range of voltage is from 0 to 250 volts (rms). Experimental results and curves will be given. The relations have been studied previously only for steady unidirectional flow and constant applied potential.

* Partially supported by a grant from Research Corporation.
[1] R. G. Packard, Phys. Rev. **89**, 906(A) (1953).
[2] P. B. Lorenz, J. Phys. Chem. **56**, 775 (1952).

J12. The Role of the Rydberg Constant in the Calculation of Ionic Radii. N. EFREMOV, *1061 Intervale Avenue, New York, New York.*—In the periodic system of ions[1] we discern 10 rows of positive and negative ions. The ions belong either to the inert gases rows, e.g., Ne-row,

$$C^{4-}-N^{3-}-O^{2-}-F^{1-}-(Ne)-Na^{1+}-Mg^{2+}-Al^{3+}-Si^{4+}-P^{5+}-S^{6+}-Cl^{7+},$$

or to the triplets rows, e.g.,

$$(Fe-Co-Ni)-Cu^{1+}-Zn^{2+}-Ga^{3+}-Ge^{4+}-As^{5+}-Se^{6+}-Br^{7+}.$$

Calculating the effective ionic radii [for crystalline lattices of NaCl type) by means of the quantization method[2]] worked out by us we use two constants P and P'. $P'=0.01096777$A, while $P=0.01462369$A. We use P for calculation of the radii of ions belonging to the rows of inert gases (e.g., Ne, Ar), while P' is used for calculation of the radii of ions belonging to the rows of triplets elements (e.g., Fe−Co−Ni). Constant P' may be obtained by the multiplication from the Rydberg constant for the atomic hydrogen (109677.7) expressed in reciprocal angstrom units by the factor 10, i.e., $P'=0.01096777$A. And $P=4/3\ P'$ or $P=(0.01096777\text{A}\times 4):3$, or $P=0.01462369$A.

[1] N. Efremov, Phys. Rev. **92**, 1081(A) (1953).
[2] N. Efremov, Bull. Am. Phys. Soc. **28**, 30 (1953).

Author Index to Papers Presented at the 1954 Austin Meeting

Arnold, Charles W. and F. A. Masten—D1
Auverman, Harry J. and Arthur E. Lockenvitz—J1
Badar, L. J. and V. P. Jacobsmeyer—G4
Banta, H. E. and R. L. Macklin—F4
Becker, Stewart and Melvin Eisner—I4
Bonner, T. W. and C. F. Cook—F6
Chuoke, Robert L.—G2
Clarkson, Henry Neal and Arthur E. Lockenvitz—J2
Class, C. M.—H1
Class, C. M., C. F. Cook, and J. T. Eisinger—H2
Cohen, B. L.—C3
Collins, R. L. and J. Rud Nielsen—D6
Cook, C. F. and T. W. Bonner—F5
Cooke, Claude E.—J11
Coon, J. B. and J. K. Ward—D4
Cowan, Alvin E. and Arthur E. Lockenvitz—G6
Crawford, J. H.—B1
Deal, W. E., Jr.—J3
Dudley, J. D. and C. M. Class—F8
Duller, N. M., W. D. Walker, J. W. Graham, and J. R. Risser—H3
Efremov, N.—J12
El-Sabban, M. Z. and J. Rud Nielsen—D7
Foster, B. P., G. S. Stanford, and L. L. Lee—C7
Ginzbarg, Arthur S. and William L. Roever—J7
Goodrich, Max—C2
Gordy, Walter—A4
Gossett, C. R., G. C. Phillips, and J. T. Eisinger—F9
Grannemann, W. W., C. W. Horton, and R. B. Watson—J10
Heaps, C. W.—G5
Hereford, F. L.—E1
Hildebrandt, Alvin F.—I3
Horton, C. W. and W. W. Grannemann—J9
Houston, W. V.—G1
Hoyer, W. A.—J6
Hughes, D. S.—A1
Lander, J. J.—B2
Lindsay, Robert—G3
Little, R. N., Jr., C. P. Cadenhead, B. P. Leonard, Jr., J. T. Prud'homme, L. D. Vincent, and J. E. Wills—F3
Marion, J. B.—F12
Marion, J. B., C. F. Cook, and T. W. Bonner—F7
McCrary, J. H., H. L. Taylor, and T. W. Bonner—F11
Mifsud, J. F.—J5
Miller, J. M. and F. A. Matsen—D2
Millett, Walter E.—G8
Mitchell, A. C. G.—A2
Mitchell, R. W. and Melvin Eisner—I2
Nereson, Norris—E4
Nielsen, J. Rud, H. H. Claassen, and Norma B. Moran—D8
Nolle, A. W.—J4
Orvis, A. L. and M. M. D. Williams—H5
Peacock, C. L., A. W. Oser, and J. F. Quin—C8
Perlman, I.—C1
Phillips, J. A.—E2
Plint, C. A., R. M. B. Small, and H. L. Welsh—D9
Reich, C. W., J. Russell, and G. C. Phillips—C6
Reynolds, J. M.—B4
Rickard, James A. and Emmett L. Hudspeth—F1
Risser, J. R. and H. C. Allen, Jr.—H8
Rollwitz, William L.—I1
Russell, J. Jr., C. W. Reich, and G. C. Phillips—C5
Russell, R. K.—D5
Scott, D. W., H. L. Reynolds, and A. Zucker—H6
Smith, D. M. and E. L. Secrest—D10
Spearman, K. R., E. L. Hudspeth, and I. L. Morgan—F2
Squire, C. F.—B3
Streetman, J. R. and F. A. Matsen—D3
Swim, R. T. and H. E. Rorschach, Jr.—G7
Talley, Harry and Robert Stump—G9
Taylor, H. L., O. Lönsjö, and T. W. Bonner—F10
Templeton, Charles C.—J8
Vallarta, M. S.—E5
Weller, Charles E.—H4
Whaling, Ward—E3
Williams, Dudley—A3
Wills, James E. and Henry R. Dvorak—H7
Windham, Pat M. and G. C. Phillips—C4

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1954

President	H. A. BETHE	Cornell University
Vice-President	R. T. BIRGE	University of California
Secretary	K. K. DARROW	Bell Telephone Laboratories (Office at Columbia University)
Treasurer	G. B. PEGRAM	Columbia University
Managing Editor	S. A. GOUDSMIT	Brookhaven National Laboratory
Local Secretary for the Pacific Coast	J. KAPLAN	University of California at Los Angeles

COUNCIL

The President, Vice-President, Secretary, Treasurer, Managing Editor, the three Past Presidents most recently retired from office, eight elected members and all Past Presidents first elected to the office of President prior to December 1932 constitute the Council which shall have general charge of the affairs of the Society.

Past Presidents now on Council: Theodore Lyman, K. T. Compton, W. F. G. Swann, C. C. Lauritsen, J. H. Van Vleck, and Enrico Fermi.

Elected Members of the Council: R. F. Bacher, E. M. Purcell, R. B. Brode, W. V. Houston, L. I. Schiff, W. Shockley, and two yet to be elected.

Please cut along this line

(To be sent to Professor E. L. Hudspeth, University of Texas, Austin 12, Texas.)

I EXPECT to attend the dinner of the American Physical Society at seven o'clock on Friday evening, February 26. My party will comprise .... persons.

(*Name*) .....

(*Address*) .....

(If you want your tickets mailed to you, send a check, made out to American Physical Society, for $2.85 per plate together with a stamped self-addressed envelope. If you want your tickets held at the desk past the deadline-hour, send check without self-addressed envelope.)